HIGH-MAGNESIUM LITHOLOGIES AND DRY FLUID METASOMATISM IN THE BUDULAN MESOSIDERITE. C. Lorenz[1], M. Nazarov[1], G. Kurat[2] and F. Brandstaetter[2], [1] Vernadsky Institute, 117975, Kosygin St. 19, Moscow, Russia (nazarov@geokhi.ru), [2] Naturhistorisches Museum, Postfach 417, A-1014, Vienna, Austria (gero.kurat@univie.ac.at)

Mesosiderites are widely believed to be impact breccias from a fractionated planetesimal. They are commonly recrystallized, dense rocks showing evidence for high temperature metamorphism. In contrast to many other meteorite classes, no traces of metasomatic processes have yet been found in these rocks. Here we report on a petrologic study of the Budulan mesosiderite and the first evidence for dry fluid metasomatism in a mesosiderite. Metasomatism manifests itself in local reduction of olivine, formation of a variety of symplectites and mobilization of Fe,Ni metal. Budulan apparently was not isolated after its formation but rather was subject to the action of a variety of fluids entering the rock via cracks which were opened at different times.

Results. Budulan is a recrystallized breccia that consists of lithic and mineral clasts with metal filling the interstitial space. The metal consists of kamacite (Ni = 5.2 wt%, Ni/Co = 13) and taenite (Ni = 30 - 50 wt%) and is commonly accompanied by schreibersite (Ni = 47 - 54 wt%). The metal fills the voids of the silicate aggregation structure and is free of shock features.

Three different silicate lithologies have been encountered: one basaltic and two peridotitic. Orthopyroxene (En66) and plagioclase (An90) are the dominant silicate phases in the basaltic lithic clasts. The silicates are similar in composition to those in other mesosiderites [1] and achondrites of the HED clan [2]. Occasionally, orthopyroxene En68Fs28Wo4 contains small (10 mm) inclusions of high-Ca pyroxene with compositions up to En40Fs12Wo48. Minor minerals in Budulan lithic clasts are silica, sulfides, phosphates, phosphides, chromite, ilmenite and rutile.

Four unusual coarse-grained lithic clasts consisting mainly of olivine were found. Two of them are exclusively composed of olivine (Fo62-65) with a Fe/Mn ratio of 35. Two other ones contain olivine Fo87-91 and minor orthopyroxene En85-89. Olivine and orthopyroxene have a Fe/Mn ratio of 36-45. Accessory phases are troilite and plagioclase (An99). Along olivine-orthopyroxene interfaces, the latter contains abundant chromite-bearing symplectites. The symplectites are similar to those described from lunar rocks by [3] and could be the result of aluminum and chromium redistribution between the silicates [4]. There is intensive secondary alteration along the numerous thin cracks and grain boundaries in the peridotitic rocks (Fig. 1). Olivine exhibits a gradual increase in Mg (Fig. 2), up to Fo97 and Fo72 for Mg-rich and Mg-poor rocks, respectively, and corresponding decrease in Fe/Mn ratio (down to 15) toward the cracks. No serpentine or other water-bearing phases were found. The cracks are commonly decorated by fine-grained (1-5 mm grain-size) symplectites (Fig. 3) which consist of kamacite (4 wt% Ni), troilite, pentlandite, orthopyroxene (En90-93 in the Mg-rich, En70 in the Mg poor rocks) and silica. However, the symplectites do not form a continuos zone along the cracks. Some cracks are filled with oxides (rust), which contain relics of kamacite (5 wt% Ni) and tetrataenite (up to 54 wt% Ni) (Fig. 5). The Ni/Co ratio in the relictic kamacite is 15 and corresponds to that of the common Budulan metal. Occasionally, chromite and Ca phosphate are present in the oxides.

Discussion. The Budulan mesosiderite contains three different silicate lithologies. The first one is a brecciated and recrystallized basaltic rock. Its silicate compositions are similar to those of other mesosiderites and HED meteorites. The restricted variation of orthopyroxene composition indicates thermal metamorphism. However, the different MgO/(MgO+FeO) ratios (Mg#) of co-existing low- and high-Ca pyroxenes signal lack of equilibrium.

The second lithology is represented by coarse-grained and recrystallized rocks consisting of olivine Fo62-65 with a Fe/Mn ratio which is similar to that in pyroxenes of HED meteorites and olivine clasts of other mesosiderites [1, 5 - 7]. These Mg-poor olivine rocks appear to be related to the HED suite. In fact, olivine of Fo65 is in equilibrium with an eucritic melt [8] and, therefore, the lithologies containing such olivine could be formed directly from this melt.

The third lithology contains high-Mg olivine (Fo89-93) whose composition exceeds that described from other mesosiderites [1, 5, 6]. Also, the reported orthopyroxene composition are always lower in Mg than En82 and, therefore, Budulan contains the most magnesian silicates compared to all other known mesosiderites. The high-Mg lithology (Fo87-91) cannot be crystallized from an eucrite melt. Possibly, this lithology could represent a residuum after partial melting of the mantle in the HED parent body.

Secondary alterations appear to be a characteristic of the olivine rocks. Apparently, the alteration could have been produced by a dry, reducing and sulfur-bearing fluid which reacted with olivine to form the metal- sulfide- enstatite- silica symplectite association. The alteration demands a mobilization of Fe and Ni because the metal and the sulfides in the symplectites contain Ni which could not have been derived from the Ni-free olivine. Vapor species that might reduce olivine and mobilize metals in the absence of H2O have been considered for the lunar environment [9]. The consideration shows that a S-bearing gas with oxygen activity buffered by CO2-CO could reduce Fe from olivine and produce carbonyl species which could be important carriers for S and metals. Metasomatism could take place in an ejecta blanket or in the mantle of the mesosiderite parent body. If taking place in the mantle, the process could cause a significant enrichment of the mantle in Mg and could lead to remobilization of Fe-Ni metal phase. However, the possibility of a nebular setting needs also to be considered as similar reduction reactions are widespread in chondrules of unequilibrated chondrites [10] and in ureilites [11].

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References: [1] Powell B. N. (1971) GCA 35, 5-34. [2] Ruzicka A. et al (1997) MAPS 32, 825-840. [3] Bell P.M. et al (1975) Proc. LSC 6th, 231-248. [4] Sack R.O. et al, (1991) GCA 55, 1111-1120. [5] Mittlefehldt D.W. (1980) EPSL 51, 29-40. [6] Nehru C. E., Zucker S. M. (1980) GCA 44, 1103-1118. [7] Rubin A. E. and Mittlefehldt D.W. (1992) GCA 56, 827-840. [8] Dodd R.T., (1981) Meteorites. Cambridge. Univ. Press, 273-274. [9] Colson R. O. (1992) Proc. LPSC 22nd, 427-436. [10] Weisberg M. et al. (1994) MAPS 29, 362-373. [11] Goodrich C. A. (1992) MAPS 27, 327-352.

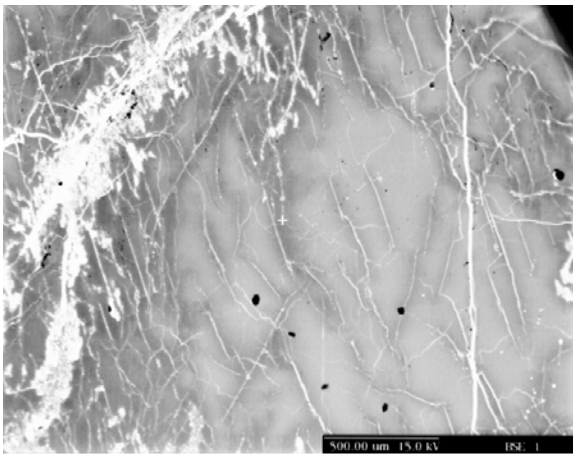

Fig. 1. The secondary alteration (reduction of Fe from olivine, dark halos following some cracks) in a Mg-rich rock fragment in Budulan. BSE image.

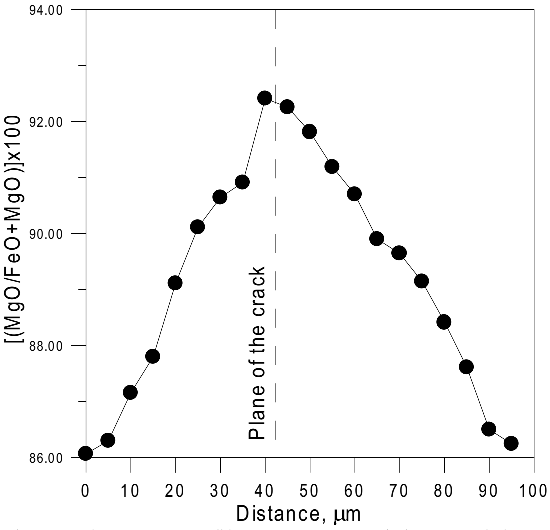

Fig. 2. The Mg# profile across a crack in Mg-rich olivine.

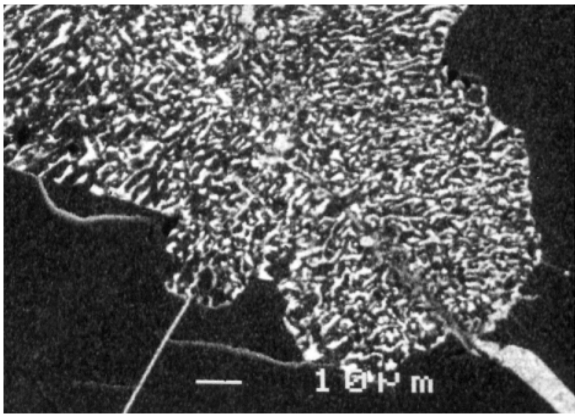

Fig. 3. BSE image of a sulfide-silica-metal-orthopyroxene symplectite associated with thin cracks in the olivine.

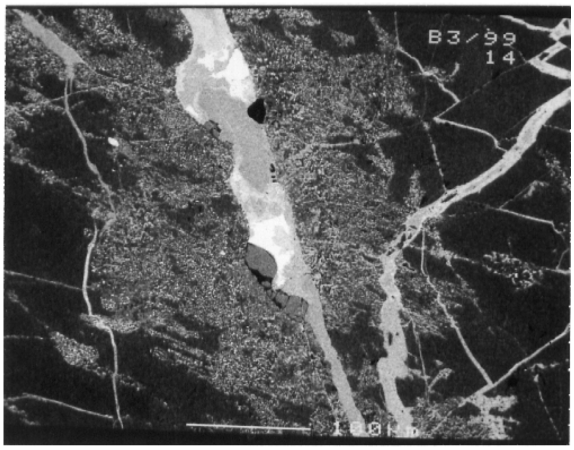

Fig. 4. Relics of kamacite and taenite (white) in an oxidized vein in Mg-rich olivine clast. The gray phase at upper center is chromite, the dark gray grains at lower center are Ca-phosphate.